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INDUSTRY SECTOR SELECTION REPORT

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Executive Summary

The Government of India and the Government of Netherlands (through the Asian Development Bank) have jointly launched a programme entitled 'Energy Efficiency Support Project (ESP)', to address the energy and environmental issues pertaining to the Indian industry. The aim of the project is to encourage the industry to take up energy efficiency investments that would lead to both energy saving and pollution reduction. The project consists of two distinct phases. Phase-I of the project primarily deals with selection of six industry sectors, where there is a substantial scope for both energy saving and pollution reduction. The chosen industry sectors will be those for which the efforts planned under phase-II of the project would yield maximum benefits in terms of improved energy use pattern and pollution reduction. Phase-II of the ESP includes various initiatives like undertaking energy and environmental audits, feasibility studies, training, promotional campaigns, etc. for the chosen industry sectors.

This report presents the outcome of the phase-I study. A total of 12 industry sectors were covered under phase-I for a detailed analysis with a view to identify six most promising ones. The study was jointly undertaken by the Tata Energy Research Institute (TERI) and the Confederation of Indian Industry (CII). Out of the 12 industry sectors chosen for the study, six sectors, i.e., fertiliser, textile, sugar, petrochemicals, chlor-alkali and aluminium were covered by TERI. The remaining six sectors, namely, cement, paper, glass & ceramics, foundry, small & medium size steel & food processing were analysed by CII. The information generated through the sectoral reviews were then analysed and a comparative evaluation was made amongst these 12 sectors to identify the six most appropriate industry sectors for the phase-II of the project.

A total of five primary attributes, namely; (i) absolute energy consumption by the sector, (ii) energy saving potential in a sector, (iii) environment improvement potential in a sector, (iv) sector responsiveness to implement energy conservation programmes and (v) chances of replication of identified energy saving measures, were used to rank 12 industry sectors.

Based on the comparative assessment of the 12 industry sectors, the sector selected for assistance under the phase-II of the ESP were; (i) pulp and paper, (ii) fertiliser (urea), (iii) sugar, (iv) cement, (v) mini-steel and (vi) textiles.

CHAPTER 1

Introduction

A programme entitled 'Energy Efficiency Support Project (ESP)', have been launched jointly by the Government of India and the Government of Netherlands (through ADB). The programme is aimed at improving the capability of Indian industry/consultants in the energy/environment field and also to encourage the Indian industry to take up energy efficiency investments that would lead to both energy saving and pollution reduction. The project has two distinct phases. Phase-I of the project deals with identification of industry sectors with high potential for energy saving and pollution reduction. Under phase-II of the project, various initiatives like undertaking energy and environmental audits, feasibility studies, training programmes, promotional campaigns, etc. will be carried out for the selected industry sectors.

The broad objectives of the phase-I study, which was jointly carried out by TERI and CII were; (i) to prepare sectoral reports for the twelve selected industry sectors and (ii) use the information available in the sectoral reports to rank these industry sectors, with a view to shortlist six most promising candidates. For preparing the sectoral reports, six sectors each were covered by TERI and CII, the details of which is provided below.

1.1 Industry sectors covered by TERI

- Fertiliser (urea)
- Textile
- Sugar
- Petrochemical (PVC and Polyester)
- Chlor-alkali (Caustic soda and Soda ash)
- Aluminium (primary)

1.2 Industry sectors covered by CII

- Cement
- Paper
- Glass and Ceramics
- Foundry
- Small and medium size steel
- Food

This report contains the executive summary of the twelve sectoral reports, the details of methodology adopted for ranking the industry sectors, the analysis and the final results of the phase-I study.

CHAPTER 2

Summary of sectoral reports

2.1 Fertiliser

Agriculture has been the mainstay of the Indian economy from the very beginning. Since the prospects of increasing the arable land are almost exhausted, the country has to depend on increasing the grain yield/hectare. One of the most important inputs required to achieve this is by the use of chemical fertilisers. During the last two decades, the growth of the Indian fertiliser industry has been spectacular and today, India ranks fourth in the world in fertliser production. In the present report, an assessment is carried out with respect to the performance of the Indian fertiliser industry, with special emphasis on energy and environmental issues. In order to provide a focussed discussion, only ammonia-urea plants are covered under the assessment. Urea was selected primarily because; (i) the manufacture of urea is most energy intensive amongst various fertiliser products and (ii) urea production accounts for 80% of the total nitrogen production in our country.

The fertiliser industry is one of the largest consumer of hydrocarbon energy. It is estimated that manufacture, packing, transport and application of 1 kg of nitrogen fertiliser requires about 2 kgs of fossil fuel. Nitrogen production capacity uses naphtha, natural gas. fuel oil and coal as feedstock. Natural gas with 45.7% share and naphtha with 28.4% share are the dominant feedstocks. Fuel oil and coal have 14.2% and 5.2% share respectively. 51% of the investment in all nitrogenous fertilisers is in the public sector companies. Ammonia is the major intermediate for production of nitrogenous and complex fertilisers. Production of ammonia constitutes major part of energy consumption in production of fertiliser products. More than 80% of energy required in production of urea is spent in ammonia production.

The performance of fertiliser plants from energy viewpoint has shown a steady improvement over the years as can be gauged from the fact that the specific energy consumption for ammonia production has progressively reduced from 14.8 Gcal in 1979-80 to 11.4 Gcal in 1992-93. The present specific energy consumption for the urea varies between 5.79 Gcal for the most efficiently running plant to 13.0 Gcal for the most inefficient one. The absolute energy consumption by this sector has been estimated at 112 Gcal. This includes the energy requirement for the fuel and the feed. It has been estimated that the total energy saving potential in the sector is 10% of the total energy use.

Many technological gaps exist in old as well as new fertiliser plants. Various revamp/retrofit options are available to modernise these plants. Some of the major energy

saving options for both ammonia and urea plants are; (i) reformer tubes of superior material, (ii) adiabatic pre-reformer for steam reforming, (iii) reduction of steam/carbon ratio, (iv) purge gas recovery unit in ammonia synthesis, (v) ammonia synthesis converter revamp, (vi) installation of urea hydrolyser stripper and (vii) use of internal heat recovery system in urea plant. Latest material of construction, better heat recovery, lower steam/carbon ratio, etc. are available to modernise reforming section of ammonia plants. Similarly, better solvents and promoters, better tower packing, use of hydraulic turbine for energy recovery, etc. offer good opportunities for energy consumption reduction in CO_2 recovery section. Synthesis converter revamp, molecular sieve drying, more active catalyst, purge gas recovery are some of the options for improving energy efficiency in ammonia plants. Use of better designed reactor with internal heat recovery and installation of urea hydrolyser stripper offer opportunities for both material and energy savings in urea plants.

Fertiliser plants are highly polluting in nature. But the industry has taken positive steps to control and minimise the release of pollutants. As of June, 1994, all the plants were found to comply with the emission standards laid down by pollution control boards. However, further scope still exists in reducing ammonia loss specially in old plants.

The performance of the industry (except for the sick units in the public sector) is quite impressive with some units achieving better specific energy consumption levels compared to design norms. However, it is recommended that appropriate provisions should be made in the retention pricing scheme (RPS) to further encourage investment in energy conservation projects. In the early phase of the RPS for fertiliser, normative consumption of various inputs was taken into account. This encouraged the improvement in energy efficiency over and above the norms. In addition, there were special fiscal incentives for implementing energy conservation measures. These schemes need to be reinstated to encourage fertiliser plants to further improve the efficiency of energy use.

Based on the assessment of this sector and its comparative evaluation with other sectors covered under Phase-I of this ADB Energy Efficiency Support Project, Fertiliser sector is recommended for Phase-II of ESP.

2.2 Textile

The Indian textile industry accounts for 20% of the total world production and contributes to 25-30% of the total value of exports from India. Due to new economic policy of the Government, there has been a tremendous growth in textile industry in the recent past. Government has announced several liberalised measures and benefits for exports and imports. As a result, there is a good competition among Indian mills to improve quality

and export their products in large quantity. This report presents a macro assessment of the cotton textile industry. The reason for selecting this particular segment stems from the fact that industry at present is predominantly cotton based which accounts for nearly 60% of the total fabric production.

Total energy consumption in this sector was about 30.56 million Gcals in 1993-94. The energy consumption in the form of coal, fuel oil and electricity were 18 million Gcals, 5.25 million Gcals, 7.31 million Gcals respectively. The cost of energy as a percentage of production cost in this sector has increased significantly during the past decade. Fuel and power accounts for 12-15% of the total cost of production at present. The trend is expected to worsen in future because of increasing fuel prices.

Overall energy saving potential in this sector is estimated to be 23%. The major energy saving measures applicable for the textile industry are listed below.

- Automatic soft flow machine for scouring, bleaching, dyeing and washing with microprocessor control system;
- Automatic drying machine for fabric;
- Energy efficient radio frequency dryer;
- Smaller wrap diameter spindles;
- Light weight ABS material pulley in ring frame.

There is also a possibility to utilise solar thermal energy in this sector primarily because of the requirement of large quantity of low grade heat in textile mills. The approximate range of investment necessary to implement above measures range from Rs 500 to Rs 40,00,000 with energy saving of 5 to 30%.

The textile industry generates both solid wastes and liquid effluents. Solid wastes like cotton fibres are generated from blow room, carding and combing sections of the mills. The source of liquid effluents are different process sections like desizing, kiering and bleaching, dyeing, printing and utilities. There are many units, mostly under the small scale, where adequate facilities are not available to comply with the emission standards laid down by Pollution Control Board.

In many units, there is a total lack of systematic energy management at the plant level. There are many reasons as to why old mills are showing disinterest towards modernisation. The type of products these units manufacture (coarse and medium yarns) have a good market in decentralised sector that does not call for stringent quality requirements. Additional factors responsible for this are the type of work culture (union activity), dearth of adequate long-term modernisation planning etc. Over the years, the condition of the mills have deteriorated to such an extent that it would require a huge investment to get these mills modernised. Many progressive mills, however, are in the

process of modernisation and expansion of their plants. These mills have also set up their own training cells and there is a growing realisation that proper training and systematic energy management at the plant level can contribute significantly to the overall profitability of the mills.

Based on the assessment of this sector and its comparative evaluation with other sectors covered under Phase-I of this ADB Energy Efficiency Support Project, Textile sector is recommended for Phase-II of ESP.

2.3 Sugar

India is the world's largest producer of sugar and the industry is expected to grow at a rate of around 5% p.a. The Indian sugar industry is unique in more than one way -cooperative sector accounts for more than 58 % of the installed capacity, atleast half of the existing sugar factories are more than 25 years old and the average crushing capacity is only 2035 TCD compared to plants of 8000 TCD and more in developed countries. Inspite of being the world's largest producer of sugar, the per capita consumption of sugar in India is only 14.6 kg compared to 30 - 50 kg in the developed countries. The sugar production is highly dependent on the availability of cane. Apart from the weather playing a crucial role in the availability of cane, the other competing uses of cane are the production of gur and khandsari - the traditional forms of sugar, manufactured in the cottage industries. The sugar industry appears to be poised for a major expansion, especially considering the record production of 14.5 million tonnes in 1994-95. On the other hand, certain sections of the industry strongly feel that the industry can face unprecedented financial crisis in the future if certain concrete steps are not taken by the Government to decontrol the industry. The sugar industry is still one of the most regulated industries in India. The controls exist right from the stage of setting up of new capacities to the sale of sugar by way of levy/non-levy quota and the regulated release of monthly quotas of sugar by the Govt to keep the sugar prices under check. The rather cyclical nature of sugar production witnessed in the past in a way explains the impacts of this controlled regime. The fall in the price of sugar in a year, which is normally due to production exceeding the demand, discourages the cane growers, who switch to other crops in the following years. This creates a deficit in production, thus resulting in a surge in market prices.

The average steam consumption of the Indian sugar mills is around 0.55 tonnes of steam per tonne of cane crushed while the average electricity consumption is around 24 Kwh per tonne of cane crushed. The Government of India has specified a steam consumption norm of 0.50 tonnes per tonne of cane crushed as a maximum limit for new factories (set up on 1987 standard specifications). The total absolute primary energy consumption in the industry is around 100 million Gcals. The energy consumption in the

Indian sugar industry is high mainly because of (i) the presence of a large number of small sized inefficient mills (ii) non-incorporation of energy saving devices and inadequate implementation of energy conservation measures. The scenario can be improved in the mills by optimising the process steam requirements, upgradation of steam generating parameters for adopting advanced cogeneration systems and by employing energy efficient technologies in various sections of the plant. Adoption of these measures can help in reducing the energy consumption in plants by around 20%.

Setting up of high pressure cogeneration plants has been identified as one of the major energy saving measures for the sugar mills. Preliminary studies carried out by various agencies have put the total cogen potential to be atleast 3500 MW. Venturing into the field of commercial cogeneration offers numerous advantages to the sugar mill owners, the major one being the possibility of additional revenue inflows by way of sale of excess electricity. This additional business opportunity can help the mills in improving their financial health. Bagasse based cogenerators feeding to the grid can also help in partly meeting the growing power demand in the country. The other major energy saving opportunities in the sugar mills are:

- steam economy in evaporator section (e.g. falling film evaporators)
- use of continuous vacuum pans
- use of hydraulic drives
- bagasse drying
- use of continuous centrifuges
- energy saving measures in boiler section (e.g. economisers, air preheaters etc.)

There are basically two sources of pollutants from sugar plants - one caused by flue gases from the boilers and the other caused by the wastewater from the various sections of the plant. Generically, the extent of pollution can be considered to be high from the sugar mills. Atleast 30% of the plants are not having adequate facilities to comply with emission standards.

Considering the immense scope for energy conservation in the sector and the social and national benefits to the country at large, it is recommended that the sugar sector be considered for assistance under the second phase of ESP. There are good opportunities for replication in the sector since there are already 450 mills and several new sugar mills are expected to come up in the near future.

Based on the assessment of this sector and its comparative evaluation with other sectors covered under Phase-I of this ADB Energy Efficiency Support Project, Sugar sector is recommended for Phase-II of ESP.

2.4 Petrochemical

The petrochemical sector plays an important role in the industrial strategies and economic growth of a country. The rate at which the sector has grown in India is quite remarkable, maintaining a double digit figure for the last few decades. There are more than 50 products based on petrochemical input. However, in order to give a focused assessment, two downstream petrochemicals have been selected for detailed review in this study : **Poly Vinyl Chloride (PVC)** which has the largest market share among plastics consumed in India and **Polyester (Polyester Filament Yarn (PFY)/Polyester Staple Fibre (PSF))** the most common synthetic raw material for textiles. Both these products are particularly energy intensive and account for a major share of total energy consumption in the petrochemical sector.

In this study, a review of the current scenario was carried out for the two downstream products based on historical performance and trends, distribution of ownership and analysis of energy consumption pattern. The study also covers the status of manufacturing technologies, overall performance of the sector with respect to capacity utilisation and specific energy consumption and identifies some major energy saving opportunities within the selected sub-sectors. Emission standards and pollution control techniques have also been dealt with in this report.

2.4.1 Polyvinyl chloride (PVC)

There are seven major producers of PVC in India, with a total installed capacity of about 550,000 TPA. The domestic consumption has shown a remarkable growth rate of about 32% during the last four years, and total production in 1994-95 was 442,000 tonnes. PVC production is predominantly in the private sector with only one major producer in the public sector. With huge demand from construction and housing sector, the consumption of PVC is expected to show a steady growth rate of atleast 12% in the future.

PVC is a fairly energy intensive sector and the net specific energy requirement for manufacture of PVC from vinyl chloride monomer (VCM) is about 2445 Mcal/tonne in Indian plants. For a production of 442,000 MT in 1994-95 the total net energy consumption in the PVC sector works out to be about 1.1×10^6 Gcals. The share of energy cost to the total production cost varies with the size and vintage of the plants and is in the range of 5 to 8%. The common forms of energy used in PVC manufacture are electricity, furnace oil and natural gas, with electricity accounting for 58% of the total energy use by this sector.

Most PVC plants in India have been set up over a decade ago. The plants are of sub-optimal size and are based on obsolete technology. It has been estimated that the total energy saving potential in this sector is 10-15% of the total energy use. Some of the

major energy saving measures include installation of higher productivity reactors, use of latest control systems, incorporation of new clean reactor technology, improved stripping process, new cyclone dryer system and improvements in steam distribution system and condensate recovery.

The liquid effluent stream from PVC plants has a high percentage of volatile chlorinated hydrocarbons which have to be treated separately. Containment of VCM and its monitoring is very important in PVC plants. All the plants, have effluent treatment facilities. However, there is scope for further reduction in VCM exposure by employing clean reactor technology and improved stripping methods.

Most of the energy conservation measures involve drastic changes in technology and require major capital investments. Till recently, PVC was in short supply and had to be imported to meet domestic demand. This coupled with high import duties, did not offer much incentive to the producers to reduce energy costs and become more competitive. However, now with the liberalisation of the economy and the reduction in import duties, units have to reduce energy costs in order to become cost competitive and sustain the desired growth rate in the future.

2.4.2 *Polyester yarn and fibre*

There are several major manufacturers of polyester filament yarn (PFY) and polyester staple fibre (PSF). The industry has made rapid progress, and recorded about 13% growth rate in the last five years. The total installed capacity of PFY and PSF is about 5.33 lakh tonnes and total production in 1994-95 was 5.15 lakh tonnes. With dwindling share of cotton fabrics in the overall per capita cloth consumption, the expected future growth rate of this sub-sector is about 15% per annum. The industry is predominantly in the private sector, with only 3 units in the public and cooperative sector.

The production of polyester fibre/yarn is an energy intensive process and the specific energy consumption is estimated to be about 9181 Mcal/tonne. For a total production of 515,000 MT in 1994-95, the absolute energy consumption for the sub-sector is estimated be about 4.71 x 10^6 Gcals. Electricity and furnace oil are the major form of energy used. Coal is also being also used in few plants. The share of energy cost as a percentage of the total production cost, varies widely, and is in the range of 6 to 9% for most plants.

With the exception of a handful of big companies, most of the Indian polyester yarn and fibre plants are much smaller in size compared to similar plants in Korea or Taiwan. Against an average installed capacity of 35,000 to 60,000 tonnes in Korea and Taiwan, the size of an Indian plant, on an average, is about 9,000 tonnes. Higher levels of productivity and lower production costs are prerequisites for competitiveness of the sector.

There is scope to achieve energy savings if about 15-20% in most plants, and thus make them more cost competitive. Some of the measures which will result in significant energy savings are upgradation of control systems, use of continuous polymerisation reactors, use of vapour absorption chiller, improvements in methanol recovery, heat recovery from stack gas and better condensate recovery.

All the PSF/PFY plants in India have effluent treatment plants. Improvements in methanol recovery from vent gases and liquid effluents could result in further saving in existing plants.

In a broader context, the deterrents to the faster growth of the industry may be classified into those which arise from inherent weaknesses afflicting it and those that stem from factors beyond its control such as government fiscal policies, trend in world raw material prices etc. The principal constraints in adoption of major energy measures are lack of adequate resources and high rates of excise and import duties. However, with increasing competition in local markets and with the entry of several large companies, the industry must make every effort to reduce cost through better energy management and improving efficiency.

Based on the comparative assessment of the 12 sectors, petrochemical sector (for the two selected downstream products) does not qualify as suitable candidate to be considered for the phase-II of the ESP.

2.5 Chlor-alkali

The Indian chlor-alkali industry represents about 2.5% of the total world production at present and produce three major inorganic chemicals, namely caustic soda, chlorine, and soda ash. These chemicals has widespread use in industries like soaps and detergents, fibres and plastics, glass, petrochemicals, pulp and paper, fertilizers, explosives, solvents, textiles and other chemicals. The alignment of the Indian chlor-alkali industry with its international counterpart is expected to elevate chlorine to a mainstream product and render caustic soda as a useful byproduct. The use of most chlorosolvents can be expected to decline due to public health concerns. The energy costs per tonne of caustic soda and soda ash manufacture has risen considerably over the years and are being covered under the present assessment.

2.5.1 Caustic soda

There are 27 major caustic soda plants in the country with a total installed capacity of 1.37 million tonnes. Out of the 27 plants, two plants are government owned and two are in joint sector. The remaining 23 plants are in the private sector. In India, four different processes viz. mercury cell, membrane cell, diaphragm cell and chemical process are used

for the production of caustic soda. As per the estimates carried out in 1992-93, the mercury cell accounts for 77% of total caustic soda production followed by membrane cell, whose share is 12%. Caustic soda manufactured by the diaphragm cell process represents only 8% of the total production. The chemical process accounts for the remaining 3% production. The most energy efficient and environmentally friendly caustic soda manufacturing process is through the membrane cell route. It produces caustic lye of 30% concentration with a specific energy consumption of 3235 kWh/t. The most polluting caustic soda (50% concentrated lye) production process is mercury cell with a specific energy consumption of 3420 kWh/t. The specific energy consumption in the diaphragm process is 3900 kWh/t. The absolute consumption of electrical energy and thermal energy in the sub-sector in 1990-91 were 3015 mil.kWh and 406300 mil. kcal respectively.

Overall energy saving potential in this sub-sector is estimated at 15%. The major energy conservation measure that can be adopted by the sub-sector is to convert mercury/diaphragm cell process to membrane cell. Converting a typical 100 tpd plant based on mercury cell technology to membrane technology, would entail an investment of about Rs 25 crores. The estimate is based on a case study prepared in 1989-90.
The major pollutants emitted from diaphragm and mercury cell-chlorine plants include chlorine, mercury vapours and carbon monoxide. Of this, mercury emission both in gaseous form and alongwith liquid effluent is a source of major concern. The average mercury discharge alongwith liquid effluent in the Indian chlor-caustic units have been observed to be more than 100 gm/t as compared to 20 gm/t in advanced countries. Mercury vapour is emitted with the gaseous streams also. The specific solid pollutants generated in the diaphragm process is minor in quantity which could be controlled with bag filters.

Government of India has reduced the custom duty from 35% to 25% for membrane cell technology and 20% reduction in the custom duty for the import of membrane. Therefore, the caustic soda sub-sector of the industry is addressing to the long overdue task of upgradation of technology by conversion to energy and non-polluting membrane cell technology and change in product mix in line with the international standards.

2.5.2 Soda ash

The commercial production of soda ash in India started in early thirties. The Indian soda ash industry have developed to such an extent that the country is not only self-sufficient but has surplus capacity. The industry has entered into the export market since 1991-92. Out of the six soda ash manufacturing units in India, three units are based on solvay process, two units follow modified solvay process (dual process) and the sixth one uses

AKZ0 drylime process. The total installed capacity of the sub-sector is 1.39 million tonnes as of March 1995 which includes installed capacity of the recently installed seventh plant, VXL India Ltd., Porbandar, Gujarat. The capacity utilisation of this sub-sector remained high at 110.8% between April 1994 to February 1995.

The two major energy consuming areas in the solvay process are (i) calcination section for the conversion of bicarbonate to soda ash and (ii) ammonia distillation section for the recovery of ammonia from ammonium chloride. These two areas together consume nearly 70% of the total energy required in the process. Calcination of limestone is not required in dual process. The specific steam in Solvay process, AKZO dry lime process and the dual process are 3.5, 2.12, 2.2 tonnes/tonne of caustic soda respectively. The corresponding electricity consumption being 150, 180-200 and 400 kWh/tonne of caustic soda production. The total energy consumption in the sector during April 1994 - February 1995 was 476643 Gcal.

Overall energy saving potential in this sub-sector is estimated at 15%. The major energy conservation schemes applicable for this sector are; (i) Use of improved heat exchangers for ammonia recovery system for soda ash production; (ii) Use of dry lime in ammonia still for heat recovery in soda ash production.

Based on an assessment of the sector and its comparative evaluation with the other sectors studied under the phase-I study, chlor-alkali sector is not considered to be an ideal candidate for phase-II of the project.

2.6 Aluminium

The aluminium industry in India is highly concentrated, with just five players accounting for the entire production capacity of 6,10,000 tonnes per annum. Three companies namely HINDALCO, INDAL and MALCO are in private sector and the remaining two, BALCO and NALCO are public sector companies. All these companies have integrated complexes. Invented over 100 years ago, Bayer-Hall-Heroult is the only available commercial technology, even today, for the production of aluminium. For the present analysis, only primary aluminium sector has been selected. The reason being that it is more energy intensive compared to secondary sector and moreover, secondary sector represents a large variety of end products making a focussed study difficult.

Domestic production of aluminium has consistently declined during the last four years from a high of 5.12 lakh tonnes in 1991-92 to 4.29 lakh tonnes in 1994-95. This is partly due to domestic demand remaining same but mainly because of closure of Belgaum smelter unit of INDAL.

The per capita consumption of aluminium in India is 0.5 kg only as against the World's average of 5 kg. With demand expected to grow by about 9 percent from present

consumption levels, even 100 percent utilization of existing capacity will not be sufficient to bridge the demand-supply gap in future. There is a fear that India, which is a net exporter of aluminium for some years, will become net importer by the turn of this century, if further capacities are not added. All the aluminium producers have plans for modernisation and expansion of existing smelters and also for greenfield projects.

Electricity, coal and fuel oil are the major forms of energy used by the sector with electricity accounting for 50% of the total energy use. Overall, energy accounts for nearly 40% of total cost of aluminium production. Based on 1994-95 figures, total energy consumed by all primary producers in the country is estimated to be 30.1 Gcal, when all the energy forms are converted to primary sources.

Energy consumption in aluminium production varies from plant to plant depending on the vintage. In India, all primary aluminium producers have set up their smelters based on different design parameters adopted at that time by their foreign know-how suppliers. NALCO has introduced the latest energy efficient systems and has the lowest specific energy consumption of 13,700 kWh per tonne of aluminium production. The remaining plants are operating at specific energy level in the range of 15,000 to 18,100 kWh per tonne of aluminium. Although Indian plants have taken a number of initiatives to improve energy efficiency but there is scope for further improvement in energy consumption, so that it can be brought down to 13,500 kWh per tonne prevailing in some of the plants elsewhere in the world.

Aluminium production is a highly energy intensive process and provides lot of scope for energy conservation. Almost all the operations require modernisation and\or modifications. A co-ordinated approach on all fronts would enable energy saving in the range of 15-20% of the total energy use. The major technological developments which could lead to significant reduction in the energy consumption in the aluminium production are given below:

- Replacement of rotary kiln by Gas Suspension Calciner.
- Adoption of tube digestion system.
- Implementation of better agitation techniques.
- Use of large size filters and additives.
- Installation of plate heat exchangers.
- Auto-control of process parameters.
- Various energy saving options in smelters.

Considerable research and development efforts are being carried out to improve the worldwide accepted Hall-Heroult technology and also to find an alternative process route which is less energy intensive and less costly for aluminium production. Several

organisations in the world are experimenting with these processes and have claimed significant advantages over the conventional Hall-Heroult process. However, these processes are either in the laboratory stage or under pilot operation and are not yet commercially established.

Aluminium production is basically polluting in nature. Almost all types of pollution i.e., gaseous ,solid and liquid effluents and wastes from different stages of aluminium production takes place. The major pollutants released during smelting are the gaseous and particulate fluoride emissions. Most of the Indian plants have provided gas cleaning installations like wet scrubbing or dry scrubbing systems to clean the cell gases before release to the atmosphere through stack. Except for two plants, all other plants comply with the pollution control standards specified by pollution control board of respective states.

Based on the assessment of this sector and its comparative evaluation with other sectors covered under the study for phase-I, this sector is not recommended for selection for the phase-II of ESP.

2.7 Ministeel

Steel being the core industry, plays an important role in the economic growth and industrial development. India is the 8th largest steel producer in the world, producing about 17.2 million tonnes of steel annually. Out of this, the ministeel industry contributes 7.60 million tonnes/year which is equivalent to 44% of the total production.

The per capita steel consumption in India is around 26kg, which is the lowest in the world. In comparison, the world average per capita consumption of steel is 149 kgs. This indicates that there is a tremendous potential for growth in Indian steel industry including ministeel industry. The projected growth potential in the ministeel industry is 13%.

A typical ministeel industry includes Arc furnace for melting, billet reheating furnace and a rolling mill for rolling and sizing the billets. There are nearly 1100 ministeel units including rerollers all over India with an annual energy consumption of Rs 14000 million and the energy cost as a percentage of manufacturing cost is around 25%.

The best specific power consumption in Indian arc furnaces ranges from 660 to 700 units per ton of melt which is higher compared to the figures of developed countries. This is primarily due to small furnace capacities, low productivity and inadequate absorption of energy saving technologies. The typical energy consumption figures of rerolling varies from 40 to 50 litres of oil per ton of finished product (billet reheating furnace) and around 100 units of electricity per ton of finished product.

There is an annual energy savings potential of Rs 1250 million in this sector based on the survey conducted by CII and other agencies. Approximately an investment of Rs 2000 million is required to tap this savings potential.

Indian arc furnaces have excellent opportunity to implement some of the latest energy saving technologies such as scrap preheating, oxygen burners, foaming slag practices, computerised automation and energy monitoring system, etc. The typical billet reheating furnaces offers energy saving opportunities such as waste heat recovery, combustion control, better insulating practices, etc.

The ministeel industry is also one of the polluting industries and some of energy saving projects in arc furnaces have significant environmental benefits.

Based on the assessment of ministeel industry and its comparative evaluation with other sectors under the study of Phase-I, this sector is recommended for the Phase-II of ESP.

2.8 Food processing

Food processing industry is fast emerging as a major industrial sector after liberalisation and economic reforms.

Food processing has emerged as a major "mother industry", essential to modern, healthy living. In India, the development of this industry has been slow and uneven. The soil in India is rich and with the country's sheer size and a coast line of continental proportions, India has the potential to emerge as one of the largest food suppliers of the world.

At present, India processes hardly 12% of raw material. This is an indicator of the immense potential for development and growth of Indian Food Processing Industry.

The food processing sector has a variety of sub-sectors and only 3 major subsectors such as Vanaspati, Dairy & Tea industry has been covered under this study as these are the major energy consumers.

The estimated annual energy consumption in three subsectors being covered is Rs 6000 million.

2.8.1 Vanaspati

Vanaspati, is fast becoming a substitute for animal based ghee. The 103 Vanaspati units in India with installed capacity of around 2.5 million tonnes produces only 1.2 million tonnes.

The total annual energy consumption in the Vanaspati units is estimated at Rs 1700 million with an estimated energy savings potential of 15%. An investment of Rs 1700 million is required to achieve the above national savings.

The major energy saving projects that can be considered in Vanaspati industry are change over from monopolar to bipolar cells, modification from batch to continuous/semi-continuous deodoriser, recovering of waste heat in process streams, besides improving the efficiency of steam generation, cold storages, optimising process parameters, etc.

2.8.2 *Dairy*

The annual milk production is around 60 million tonne in the 465 dairy units in India. The annual energy consumption of the dairy sub-sector is around Rs 2150 million and the energy cost as a percentage of manufacturing cost is around 30 to 35% and significant portion of the energy consumption is on the refrigeration system.

The various studies carried out by CII and other agencies indicate a savings potential of 16% equivalent to Rs 350 million per year. An investment of Rs 800 million is required to tap the above savings potential. Some of the major energy saving measures are fine-tuning of process parameters, recycling of waste heat, optimisation of utilities, boilers, chilled water system, fired heaters, etc.

2.8.3 *Tea*

India ranks first in the world in tea production and approximately 1000 tea units in India produce around 0.76 million tonnes per year. Tea is mainly grown in Assam, West Bengal, Tamil Nadu and Kerala which account for 98.5% of the overall national tea production.

The annual energy consumption in Indian tea industry is around Rs 2300 million and the energy cost as a percentage of manufacturing cost is around 10%. The energy savings potential in tea sub-sector is also around 10% which is equivalent to Rs 230 million and an investment of Rs 500 million is required for achieving the savings. The energy saving measures include the re-design of firing system and driers, recycling of waste heat, utilising non-conventional energy sources, etc. besides improving the plant utilities such as diesel generators, hot air generators, electrical distribution systems, etc.

Based on the assessment of food processing industry and its comparative evaluation with other sectors under the study of Phase-I, this sector is not recommended for Phase-II of ESP.

2.9 Paper

Indian Paper industry is over hundred years old and has its moorings over its hoary antiquity. Over the years under controlled economy, it has rolled out a slow growth path frequently confronted with a plethora of constraints ranging from raw material availability,

antiquated technology, uneconomic plant sizes and inadequate environment management practices. Despite these handicaps the capacity in Pulp & Paper industry has grown thirty times from a paltry 0.135 million tonnes in the early fifties to the present level of 4 million tonnes installed capacity. Growing literacy, growth in service sector, fast increasing consumerism and higher growth of industrial production will stimulate the demand for paper and the growth potential of paper industry is projected at 14.6%.

The 380 paper mills in India produce variety of paper products such as writing and printing paper, kraft, board, newsprint, etc. The Indian Pulp & Paper industry has a mix of large integrated paper plants (> 25,000 tonnes per annum capacity) medium and small size paper mills based on waste paper.

The paper industry is also energy intensive and is the sixth largest consumer of commercial energy in the country. The energy cost as a percentage of manufacturing cost is 25% and energy conservation is strongly pursued as one of the attractive options for improving profitability in the Indian Pulp & Paper industry.

The various energy conservation surveys conducted by CII, indicates a saving potential of 20%, equivalent to an annual saving of Rs 2500 million. The estimated investment to achieve the savings is Rs 4000 million. The Pulp & Paper industry has an attractive cogeneration potential of over 100 MW, in addition to the existing cogeneration plants and this can be a thrust area of Phase-II of the ADB project.

Paper industry offers several attractive investment opportunities such as upgradation of paper machine press section to have 42 - 45% dryness, installation of 6 effect evaporators, rapid displacement heating system in digestors, moisture control for paper machine, etc.

Pulp & Paper industry is one of the highly polluting industry and several energy saving projects have substantial benefits on the environmental front. For instance, the installation of chemical recovery units in medium size agro based mills have substantial environmental benefit in addition to energy and chemical savings.

Based on the assessment of this sector and its comparative evaluation with other sectors covered under Phase-I of this ADB Energy Efficiency Project, paper sector is recommended for Phase-II of ESP.

2.10 Glass & Ceramics

Glass and Ceramic industry is an age old industry and has evolved over the centuries from the potters wheel to a modernised industry with micro processor controls and data loggers. Glass & Ceramic industry is one of the fast growing industry with a projected growth rate of 8%.

2.10.1 Glass

This survey covers mainly sheet glass, container glass and lamp manufacturing units as these are major types of glass industry. The estimated energy consumption is around Rs 4000 million in the 600 glass factories all over India. The energy cost as a percentage of manufacturing cost is significant and it is around 30%.

The various surveys conducted by CII and other agencies in India have indicated an energy savings potential of 15%, which is equivalent to an annual savings of Rs 600 million. The investment required for achieving the above savings is Rs 1500 million.

The major energy consumer in the glass industry is the glass melting furnaces, which accounts for 80% of the thermal energy consumption. Normally the campaign life of the glass furnace is 6 to 7 years and furnaces are rebuilt. Timing of furnace modification for energy savings during rebuild present an excellent and easy opportunity for implementation.

The energy savings projects includes installation of multiple pass regeneration, installation of variable frequency drives for fans and cooling blowers, improvement in furnace insulation, etc.

2.10.2 Ceramics

Three types of ceramic industry namely Electroporcelain, Sanitaryware and refractories has been covered as they are the major energy consumers. Nearly 500 ceramic manufacturing units in India consume energy worth Rs 2250 million per year. There is an energy savings potential of 15% in ceramics industry based on survey conducted by CII and other agencies which is equivalent to annual savings of Rs 350 million. The investment required is Rs 700 million for achieving the above savings.

The typical energy saving projects in ceramics industry includes improved loading of the kilns, utilisation of better refractory materials for insulation, application of low thermal mass, combustion controls systems, recycling of waste heat, design modifications in kilns & driers replacing traditional designs (eg., downdraft kilns) by mini-tunnel and energy efficient versions.

Particulate emissions and gaseous pollutants are the areas of concern and majority of the energy conservation projects involving reduction in thermal energy has the advantage of directly reducing CO_2 and particulate emissions.

Based on the assessment of Glass & Ceramics sector and its comparative evaluation with other sectors covered under the study of Phase-I, this sector is not recommended for the Phase-II of ESP.

2.11 Cement

Cement is one of the core industries which plays a vital role in the growth of our nation. India ranks fifth among the Cement producing countries in the world and has come a long way since the installation of first cement plant at Porbundar in 1914. India has the requisite quality and quantity of cement grade limestone deposits backed by adequate coal reserves. Over the years, India has acquired a high degree of managerial expertise and technical skill enabling efficient and economic operation of cement plants. India is thus poised for a major role in global cement production and reach a dominant position in cement/clinker export market.

The cement industry is also highly energy intensive and ranks only second to the Iron & Steel industry in terms of overall commercial energy consumption in the country.

The Indian Cement Industry has a mix of major and mini cement plants (below 200 tpd capacity). There are 104 major cement plants with an installed capacity of 71.26 million tonnes which accounts for 97% of the annual cement production. Only major cement plants have been considered for analysis due to the above reason.

The energy cost as a percentage of manufacturing cost is around 40% and this has been the prime reason for the high responsiveness to energy conservation in Indian Cement industry. The drop in specific energy consumption in Indian Cement plants has been spectacular.

	1991 - 92	1993 - 94
Specific electrical energy consumption (units/ton of cement)	122	114
Specific thermal energy consumption (kcal/kg of clinker)	930	880

Nearly ten cement plants are presently operating below 100 units/ton of cement and their energy performance are comparable to international best standards. New cement plants are being designed for a specific power consumption of 72 units/ton of cement, which indicates the stress given to energy conservation in Indian Cement industry.

The various studies conducted by CII indicates a savings potential of 10% in Indian cement industry which is equivalent to Rs 3000 million. Approximately investment of Rs 6000 million is required to achieve the projected energy savings.

Cement industry offers several attractive energy saving investment opportunities such as conversion of pneumatic to mechanical conveying, installation of slip power recovery system and variable frequency drives, installation of low pressure drop cyclones, cogeneration, high efficiency grate coolers, multichannel burners, etc.

Cement industry produces particulate emissions and this has significant impact on the environment. The energy saving projects in Cement industry have huge direct benefits on environmental front.

Based on the assessment of this sector and its comparative evaluation with other sectors covered under Phase-I of this ADB Energy Efficiency Support Project, Cement sector is recommended for Phase-II of ESP.

2.12 Foundry

Though the Indian Foundry industry in India is 2000 years old, the industry in modern lines came into being only after independence. In the last 25 years, this industry has emerged as a key feeder industry catering to the wide range of user sectors such as automobile, shipping, machine tool, textile, heavy machinery, etc.

The study of this sector covers mainly ferrous foundry which constitutes bulk of the castings produced. The ferrous foundry can be further classified into cast iron foundry and steel foundry and the majority of the Indian plants are cast iron foundry. There are nearly 1800 foundries in the organised sector with an installed capacity of 3.0 million tonnes per year producing only 2 million tonnes. The future growth potential of this industry is projected at a modest 5%.

The Indian Foundry is also a significant consumer of energy, amounting to Rs 6250 million per year. The various surveys conducted by CII indicates an annual savings potential of atleast 10% in the Indian Foundries which is equivalent to Rs 600 million per year. An investment of Rs 1000 million is required to tap the savings potential in this sector.

A typical foundry industry uses induction furnaces or cupolas for melting and the energy cost as a percentage of manufacturing cost is as high as 16%. Some of the major energy measures in foundries includes conversion of main frequency furnace to medium frequency furnace, improved designs to minimise material recirculation, proper molten metal temperature monitoring system, computerised automation and energy monitoring system in furnaces, improving draft system conversion from cold blast to hot blast system in cupola, etc.

The foundry industry is one of the highly polluting industry and many units are yet to comply with emission and pollution standards.

Based on the assessment of Foundry and its comparative evaluation with other sectors under the study of Phase-I, this sector is not recommended for Phase-II of ESP.

CHAPTER 3

Methodology for sector selection

The information provided in the twelve sectoral reports were analysed to rank the industry sectors, the methodology for which is detailed in this section. A total of five primary attributes, as listed below, were chosen to select the six most promising industry sectors.

(i) Absolute energy consumption by the sector,

(ii) Energy saving potential in the sector,

(iii) Environment improvement potential in the sector,

(iv) Sector responsiveness to implement energy conservation/environment improvement programmes.

(iv) Chances of replication

Given the relative importance, different weightage factors were assigned to each of the attributes. The primary attributes listed above were considered to be further dependent on a set of secondary attributes. The various attributes considered for ranking the sectors alongwith their corresponding weightage factors are listed in **table 3.01**. The individual sectors were ranked on a 12 point scale for each of the attributes and the weighted ranking then added up to arrive at the final ranking. Industry secotrs that ranked from 1 to 6 were finally selected for assistance under phase-II of the ESP. For ranking purpose, efforts have been made to refer to the actual data for different attributes as provided in the detailed sectoral reports. However, for sectors/attributes, where such information are not available, the ranking was done as per the best estimates. A consolidated bibliography of various sources that were referred to for preparation of sectoral reports and also for sector ranking is provided in **annexure 3.01**. The significance of each of the attributes considered and the methodology adopted to rank the sectors for these attributes are briefly discussed below.

3.1 Absolute energy consumption in the sector (Primary attribute 1)

The absolute energy consumption in a sector is one of the important attributes which has a major bearing on the overall energy saving potential in the sector. The sector having the highest absolute energy consumption was given a rating 1 while the sector with minimum absolute energy consumption was assigned a rating of 12 on the 12 point scale.

Table 3.01. The various attributes considered for ranking of sectors

S.No.	*Primary attributes (weightage factor)*	*Secondary attributes (weightage factor)*	
1.	Absolute energy consumption by the sector (0.20)	-	
2.	Energy saving potential in the sector (0.25)	(i)	Percentage energy saving potential in the sector (0.5)
		(ii)	Number of commercially viable energy saving investment opportunities (0.5)
3.	Environment improvement potential in the sector (0.15)	(i)	Extent of pollution generated (0.5)
		(ii)	Plants not having adequate facilities to comply with emission standards (0.5)
4.	Sector responsiveness to implement energy savings/ environment improvement programmes (0.20)	(i)	Energy cost as %age of product cost (0.40)
		(ii)	Financial health of the enterprises (0.25)
		(iii)	Market driven forces (0.15)
		(iv)	In-house competence (0.20)
5.	Chances of replication (0.20)	(i)	Number of units in the sector (0.6)
		(ii)	Future growth rate (0.4)

3.2 Energy saving potential in the sector (Primary attribute 2)

The energy saving potential in any sector was considered to be a function of two secondary attributes (as shown in table 3.01), some selected details of which are described below.

3.2.1 Possible scope for energy conservation in the sector

Certain industrial sectors offer considerable scope for energy conservation while there are others where the scope is limited. The sector which offers maximum energy conservation potential (in %age terms) gets rating 1 while sector where energy saving potential is minimum gets rating 12. If the percentage of energy saving potential is same for two sectors, then the sector with higher absolute energy consumption was given a better ranking.

3.2.2 Number of commercially viable energy saving investment opportunities (medium and long term)

The sector where maximum number of commercially viable energy conservation opportunities are available gets a rating 1 while the sector with minimum number of

opportunities gets a rating 12. If the number of projects are same in two or more sectors, then the sector with higher % energy savings was given a better ranking.

3.3 Environmental improvement potential (Primary attribute 3)

This has been determined based on the general status of the sector regarding performance on the environmental front. This includes (A) the extent of pollution caused by a sector and (B) plants not having adequate facilities to comply with emission standards. The sector which causes maximum pollution gets a rating 1 under 'A' and sector with maximum number of plants not having facilities to comply with the emission standards laid by the pollution control boards, gets a rating 1 under 'B'. In case of any tie in ranking under 'B', other factors in terms of priority considered are:

sector which is generically more polluting gets a higher ranking

Sector with more number of units gets a higher ranking

3.4 Sector responsiveness to implement energy conservation/ environmental improvement programmes (Primary attribute 4)

The responsiveness of various units in a sector is a very important factor and would determine the pace of implementation of energy conservation/ environmental improvement programmes in that sector. Although rating of the sectors for this attribute is somewhat subjective in nature, attempts have been made to rate them on the basis of four secondary attributes.

3.4.1 Energy cost as a percentage of total cost

The sector where energy costs as a % of total cost of production is the highest gets a rating 1 while sector where this figure is lowest gets a rating 12. This factor is very crucial in judging the sector responsiveness because the sectors which are energy intensive would be more forthcoming in implementation of energy conservation measures. In case the energy cost is same for two sectors, the general responsiveness of the sector to implement energy conservation programmes and the size of the sector (in terms of number of units) were considered.

3.4.2 Financial health of the enterprises

The financial health of the enterprises within a sector determines the investment capabilities and their ability to mobilise funds for implementing energy conservation/ environmental improvement measures. Sector with the best financial health gets a rating 1 and sector with worst financial health gets rating 12.

3.4.3 *Existence of market driven forces*

The demand/supply situation and the Government regulations have a considerable impact on the attitude of the units towards prioritisation of energy conservation programmes. The sector where market driven forces are minimal gets a rating 12.

3.4.4 *In-house competence*

The in-house competence is the technical knowledge and skill of the plant personnel to understand and implement the energy conservation projects effectively. The sector with qualified manpower and good track record of innovative work was assigned a rating of 1.

3.5 Possibilities of replication (Primary attribute 5)

The replica effect of any energy saving/pollution reduction measure within a sector can contribute significantly in accelerating the pace of reform in the sector. Additionally, it will also help in carrying forward the programme beyond the period of intervention/ assistance. The replica effect is considered to be a function of two secondary attributes as discussed below.

3.5.1

The sector with maximum number of units gets a rating 1 while the sector with minimum number of units was assigned a rating of 12.

3.5.2 *Future growth rate*

The sector with maximum growth rate was given the first rating and the one with minimum growth rate was ranked twelfth.

3.6 Ranking of various sectors

The ranking of the various sectors has been done in accordance with the methodology detailed in section 3.0. The data used for ranking the sector for various attributes was taken from the 12 sectoral reports and is summarised in **Table 3.02.**

3.6.1 *Sector rankings for absolute energy consumption*

Ranking of sectors with regard to absolute energy consumption is provided in **table 3.03.** These rankings have been arrived at based upon the data of absolute energy consumption in 1994-95 for various sectors. For computing the absolute energy consumption, different energy forms, i.e., coal, oil, gas, electricity, etc., were converted to primary energy form in terms of million Kcal or Gcal. If the absolute energy consumption was found to be the same for two sectors (as is the case with 'Food' and 'Glass & Ceramics'), the sector

Table 3.02. Summary of data for industry sectors for the purpose of sector selection

S.No.	*Data*	*Fertiliser*	*Textile*	*Sugar*	*Petro-chemicals (PVC & Polyester)*	*Chlor-alkali*	*Aluminium*	*Mini-steel*	*Food process-ing*	*Paper*	*Glass & Ceramics*	*Cement*	*Foundry*
1	Number of operating units in the sector	35	1142	450	44	32	7	1100	1584	300	1000	104	1800
2	Demand growth (%)	5	4.2	5	13.6	7.9	9	13	5	14.6	8	8.5	5
3	Absolute energy consumption by the sector (million gcal)	112	52.5	100	5.8	20.0	30.1	27	15	26	15	67	14
4	Energy cost as a percentage of total manufacturing cost (%)	60	13	12	7	30-35	40	25	30	25	30	40	15
5	Possible scope for energy conservation in the sector (%)	10	20-25	20 + Co-generation	15	15	15-20	9	13	20	15	10	10
6	Number of medium and long term commercially viable energy saving investment opportunities	10	5	7	9	2	6	9	3	17	5	15	4
7	Number of plants not having adequate facilities to comply with emission standards in the sector (%)	0	70-75	30	0	0	28	70-75	70-75	23	70-75	15	70-75

having higher energy saving potential and more thermal energy usage was given a higher rating.

3.6.2 *Sector rankings for energy saving potential*

Table 3.04 shows the sectoral ranking with regard to the energy saving potential. These have been arrived at based upon the sectoral data relating to the two secondary attributes viz. scope for energy conservation and the number of commercially viable energy saving opportunities in the sector. Since the broad objective of the project is to identify investment opportunities which lead to considerable energy savings, only medium term and long term opportunities have been considered. As can be seen from table 3.04, the sub total for two sectors namely Aluminium and Petro-chemicals is the same. Petrochemicals, however, was assigned a higher ranking because (i) it has more number of energy saving projects and (ii) the possibility of these getting implemented is more in petrochemicals due to the fact that the number of plants in this sector are far more than in aluminium. Similar considerations were taken into account while rating Mini-steel & Chlor-alkali and Cement & Fertlisers.

3.6.3 *Sector ranking for environment improvement potential*

Table 3.05 gives the ratings for the 12 sectors with regard to environment improvement potential. These have been arrived at based upon the sectoral information relating to the two secondary attributes viz. extent of pollution caused by a sector and percentage of plants in this sector not having adequate facilities to comply with the emission standards.

To rate the industry sectors on the pollution front, alongwith consideration like type and nature of pollutants and their long term impact on society, the following factors were also considered for ranking the sectors.

- the sector with higher thermal energy consumption was given a higher ranking.
- the sector with more of water pollution was assigned a higher ranking.
- The sectors contributing to emission of toxic material (e.g. the mercury pollution in chlor alkali sector, the pollution due to fluorides in aluminium sector etc) were given a higher ranking.

For industry sectors having same ranking number, factors like type of pollutants and the emission performance of the industrial units within the sector were considered.

Table 3.03. Sector ranking for absolute energy consumption

Attribute	*Aluminium*	*Textile*	*Chlor Alkali*	*Petro-chemicals (PVC & Polyster)*	*Fertilizer*	*Sugar*	*Cement*	*Pulp & Paper*	*Foundry*	*Mini steel*	*Food*	*Glass & Ceramics*
Rating	5	4	8	12	1	2	3	7	11	6	10	9

Table 3.04. Sector ranking for energy saving potential

Attribute	*WF*	*Aluminium*	*Textile*	*Chlor Alkali*	*Petro-chemicals (PVC & Polyster)*	*Fertilizer*	*Sugar*	*Cement*	*Pulp & Paper*	*Foundry*	*Mini steel*	*Food*	*Glass & Ceramics*
Scope for energy conservation	0.5	4	2	5	7	9	1	10	3	11	12	8	6
No. of energy saving opportunities	0.5	7	8	12	4	3	6	2	1	10	5	11	9
Sub total		5.5	5	8.5	5.5	6	3.5	6	2	10.5	8.5	9.5	7.5
Rating		5	3	10	4	7	2	6	1	12	9	11	8

Table 3.05. Sector ranking for environmental improvement potential

Attribute	*WF*	*Aluminium*	*Textile*	*Chlor Alkali*	*Petro-chemicals (PVC & Polyster)*	*Fertilizer*	*Sugar*	*Cement*	*Pulp & Paper*	*Foundry*	*Mini steel*	*Food*	*Glass & Ceramics*
Extent of pollution caused	0.5	8	10	3	11	2	6	7	1	4	5	12	9
Plants not having adequate facilities to comply with norms	0.5	7	4	10	12	11	6	9	8	1	2	3	5
Sub total		7.5	7	6.5	11.5	6.5	6	8	4.5	2.5	3.5	7.5	7
Rating		9	7	6	12	5	4	11	3	1	2	10	8

Table 3.06. Ranking for sector responsiveness to implement energy conservation/environment improvement programmes

Attribute	*WF*	*Aluminium*	*Textile*	*Chlor Alkali*	*Petro-chemicals (PVC & Polyster)*	*Fertilizer*	*Sugar*	*Cement*	*Pulp & Paper*	*Foundry*	*Mini steel*	*Food*	*Glass & Ceramics*
Energy cost as a % of total cost	0.4	3	10	4	12	1	11	2	7	9	8	5	6
Financial health of enterprises	0.25	1	8	5	4	3	7	2	6	12	9	11	10
Market driven forces	0.15	10	6	4	9	11	12	3	5	1	2	8	7
In house competence	0.2	4	9	6	3	1	7	2	5	12	8	11	10
Sub total		3.75	8.7	4.65	7.75	3	9.35	2.15	6.05	9.15	7.35	8.15	7.95
Rating		3	10	4	7	2	12	1	5	11	6	9	8

3.6.4 *Sector rankings for sector responsiveness*

Table 3.06 gives the ratings with regard to sector responsiveness to implement energy conservation and environment improvement programmes. These have been arrived at based upon the sectoral information relating to the four secondary attributes viz. (i) energy cost as a % of total cost (ii) financial health of enterprises (iii) market driven forces and (iv) In house competence. The secondary attributes (ii) to (iv) are subjective in nature and rating for these has been decided based upon a number of variables. Some of the factors considered are the ownership pattern in the sector (private/public/cooperative), vintage of the plants, demand supply situation, existence of administered pricing mechanisms, technical skills of the operating personnel and the existing consultancy capabilities in the sector. The market driven forces assume a lot of importance in the present industrial climate in the country, mainly due to the high growth being witnessed in a large number of sectors and consequent opportunities available to the units to expand capacities to meet the growing demand. Given the fact that the investment capabilities of units are rather limited, the plants naturally tend to select their investments based upon the financial rates of return of competing investment options available at a particular time. The sectors which can easily pass on the increased energy cost to the consumers would tend to be relatively reluctant to invest in energy saving measures.

3.6.5 *Sector rankings for replica effect*

Table 3.07 gives the ratings for the 12 sectors for the replica effect. These have been arrived at based upon the sectoral information relating to the two secondary attributes, viz., number of units within a sector and the future growth rate expected in the sector. For sectors having similar growth rate, the one having more number of units was assigned a better rating.

A **consolidated chart showing the overall ranking** is shown in **table 3.08**.

Table 3.07. Ranking for the replica effect

Attribute	WF	Aluminium	Textile	Chlor Alkali	Petro-chemicals (PVC & Polyster)	Fertilizer	Sugar	Cement	Pulp & Paper	Foundry	Mini steel	Food	Glass & Ceramics
Number of units in the	0.6	12	3	11	9	10	6	8	7	1	4	2	5
Future growth rate expected	0.4	4	12	7	2	11	8	5	1	9	3	10	6
Sub total		8.8	6.6	9.4	6.2	10.4	6.8	6.8	4.6	4.2	3.6	5.2	5.4
Rating		10	7	11	6	12	9	8	3	2	1	4	5

Table 3.08. Overall ranking of the twelve industry sectors

Attribute	WF	Aluminium	Textile	Chlor Alkali	Petro-chemicals (PVC & Polyster)	Fertilizer	Sugar	Cement	Pulp & Paper	Foundry	Mini steel	Food	Glass & Ceramics
Absolute energy consumption	0.2	5	4	8	12	1	2	3	7	11	6	10	9
Energy saving potential	0.25	5	3	10	4	7	2	6	1	12	9	11	8
Environment improvement potential	0.15	9	7	6	12	5	4	11	3	1	2	10	8
Sector responsiveness	0.2	3	10	4	7	2	12	1	5	11	6	9	8
Chances of replication	0.2	10	7	11	6	12	9	8	3	2	1	4	5
Total		6.2	6	8	7.8	5.5	5.7	5.55	3.7	7.95	5.15	8.85	7.6
RANKING		7	6	11	9	3	5	4	1	10	2	12	8

CHAPTER 4

Conclusion

Based on the sectoral analysis, an attempt has been made to rank the 12 industrial sectors in order of their importance with regard to the Energy Efficiency Support Project. A methodology has been designed to rank the different sectors and identify the 6 most promising ones, for which, the efforts planned under phase-II of the ESP will yield maximum benefits. Based on various identified attributes and their assigned weightage factors, the 6 sectors that are finally selected and proposed to be covered under the ESP are:

- Fertiliser
- Textile
- Sugar
- Mini steel
- Paper
- Cement

Under phase-II of the project, various initiatives like undertaking energy and environmental audits, feasibility studies, training programmes, promotional campaigns, etc. will be carried out for six selected sectors. The energy and environment audits component involves studies in a few selected plants with the aim of enhancing energy efficiency and improving the environment. The training programmes would try to upgrade the skills of local consultants and industry personnel on the energy and environment front. Suitable publicity campaigns aided by audio-visuals/materials to increase awareness and participation in energy/environment improvement programmes would also be undertaken.

ANNEXURE 3.01

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